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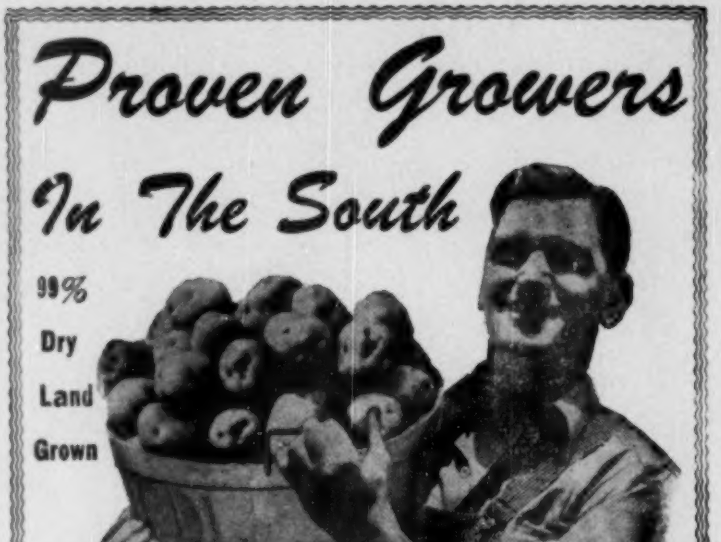
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ADDITIONAL BLIGHT-RESISTANT VARIETIES

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(Accepted for publication, Dec. 30, 1949)

As noted in a previous issue of this Journal (24:335) additional varieties have been named and released to seed producers for introduction. All of these varieties, as well as most of those previously described, were actually immune from blight in repeated inoculations in the greenhouse and in field test plots where blight became abundant on susceptible varieties. However, in 1947 late blight, caused by *Phytophthora infestans,* became prevalent in mid-July in many parts of New York and spread rapidly for several weeks. Occasional fields were totally destroyed. As late as the 12th of September, a small plot containing the 12 named varieties was entirely free from blight although susceptible varieties nearby were totally dead with blight. On the 18th of September, however, blight was found in slight amount on every one of the twelve.

In the case of the early-maturing varieties only occasional senescent leaves remained to show infection but on the late varieties the infection was not confined to senescent leaves but also was found on the green terminal leaflets. The total amount of infection was so slight that considerable search on the 24 plants of the variety Fillmore was necessary before a single lesion was found. Unfortunately, frost killed all of the plants a few days later so that no further observations were possible.

The technical aspects of this situation were presented by Mills and Peterson at the Annual Meeting of the Association and abstracted in this Journal (26:98). It will suffice here to state: (1) that the blight appeared in 1947 much earlier than usual (mid-July), (2) that weather conditions were more favorable for spread of blight than has been experienced in 30 years, (3) that there is no indication that an obscure "race" of the parasite was brought to light by the presence of these resistant plants in that field, (4) that "Several genes are concerned in resistance to *P. infestans*", (5) that the virulence of the common field race of *P. infestans* is increased on certain *demissum* hybrids by passage by way of senescent leaves and thereafter maintains the higher level of virulence for all plants of similar genetic constitution in respect of blight resistance.

At the present time it is impossible to say how widely useful these varieties may prove to be. It has been recognized from the outset that some of them have a very limited range of usefulness but that any variety which is grown at all needs to have a name. Complete and detailed descriptions have been prepared and are on permanent file at Cornell University. It does not appear important or necessary at the present time to publish the detailed descriptions. An exception is made in the case of Essex inasmuch as this variety is already being grown rather extensively. Every effort is now directed toward the development of varieties that are immune from all races of the parasite. In the meantime the varieties which were released to growers cannot be recalled, so that at least brief descriptions of them seem imperative.

Essex

Released for increase at the Rochester meeting of Empire State Potato Club, January, 1947.

Origin

Essex and Glenmeer are sibs. The origin of these varieties is shown in the parentage chart. In this chart the number 860 is Krantz' unnamed seedling 41-2-10-1, whereas the number 1152 is also an unnamed seedling obtained from Dr. Julian Miller, Baton Rouge, Louisiana. Doctor Miller states that this seedling was obtained from a selfing of the variety Triumph. The seedling, as grown at Ithaca, is not strictly determinate like its parent and its maturity date is late rather than early.

- DAB
  - ABX/6
    - DL/1 ♂
      - 860 ♂
      - 672/19 ← 398 F_2
        - Rural New Yorker No. 2
        - 178 (*demissum*) ♂
    - Alma
      - Early Sunrise
      - Erste von Frömsdorf ♂
  - 1152, F_2, Triumph ♂

Description of Essex

Habit. Plants emerge as 1 to 5, usually 2 or 3, strong, erect stalks which attain a height of 50 to 60 cm., and become dense by short axillary shoots. The stalks are determinate, spread with age but remain essentially erect until maturity. *Stems,* large, thick, green throughout, occasional white hairs; *wings,* not swollen, not colored; *internodes,* short, 2.5 to 4 cm. long; *stipules,* a pair, large, leaflike. clasping; *leaves* dark green, 20-36cm., open; *petioles,* green, 5-10 cm channel, green, shallow hairs in channel give a whitish appearance; *leaflets,* 3 or 4 pairs, usually 4, dark green, smooth, appear glaucous but have a few short white hairs, elliptic with acuminate tips; mean length 64.0± .73 mm.; mean width 44.11± .51 mm.; index 68.98± .63 *petiolules,* short 2-4 mm.; *folioles,* usually 1 pair between each pair of leaflets, small, short stalked. *Inflorescence,* large, 12 or more flowers, the first flower of each cluster borne on a distinctly longer pedicel as in *S. demissum; peduncle,* 10-12 cm., distinctly grayish color due to longish white hairs; *articulation,* conspicuous by a ring of hairs and by reduction in diameter of pedicel, *calyx,* lobes green, short acuminate tips, fairly long white hairs as on peduncle; *corolla,* pale vinaceous drab (R) fading long white hairs as on drab areas persisting at the sinus, large (3 cm.), rotate, very shallow sinus, teeth large with a broad base; *stamens,* large, plump, primuline yellow (R); *style,* rather short but exceeding the stamens, colorless,

cylindric; *stigma*, greenish, globular; *pollen*, moderately abundant but only occasional grains are fertile. *Tubers*, ovoid with blunt ends. Weight and measurements based on 99-tuber sample. Mean weight 223.47± 5.34 gms.; mean length 82.52± 9. mm.; mean width 80.27± .8 mm.; mean thickness 59.02± .6 mm.; index (width to length) 96.77± .81; index (width to length) 96.77± .81; index (thickness to length) 71.27± .71; index (width to thickness) 73.15± .71; skin, warm buff (R); eyes, fleet to moderately deep; eyebrows, conspicuous; flesh, white; maturity, approximately 110 days.

Characteristics

Essex presents a fine appearance in the field. It continues nearly erect throughout its season and is essentially determinate in type of growth. The stalks are thick and sturdy and the foliage is deep green The set of tubers is exceptionally heavy and in cool, moist seasons some phenomenal yields have been recorded. When the plants a . retarded in their growth by heat and drought they do not attain sufficient size to mature all of the tubers set with the result that there are a great many small potatoes. The variety emerged in Essex County, New York (Adirondack area), whence its name, and is well adapted to that area.

In areas where heat and drought are factors the grower will have to be skilled in maintaining sufficient soil moisture to keep the plants growing. Skillful use of irrigation, of course, would eliminate this shortcoming. Alternating periods of extreme dry and wet soil conditions, whether natural or artificial, may result in the production of knobby tubers.

The shape and appearance of the tuber is not outstandingly attractive. Those who are accustomed to Cobbler will not find these characteristics objectionable.

Cooking quality, so far as recorded, has varied from fair to very good.

The number and distribution of eyes with lack of strong dominance makes the variety easy to prepare for planting.

Reaction to Diseases

With the onset of heat and drought the foliage exhibits a strong physiological rolling of the leaflets throughout the plant. If rain comes soon enough the leaflets flatten out again.

Essex has been inoculated repeatedly in the greenhouse with *P. infestans* and has been exposed to natural spread of blight in the field. No infection ever was noted until the 18th of September, 1947, when a few lesions were found on a few senescent leaves. Tuber resistance is unknown.

Owing to its relatively early maturity the variety probably can be

grown in most places without fear of blight or rot. Such a condition should continue to prevail until there is opportunity for the natural development of a culture virulent to Essex with the subsequent perennation of this race in the tubers. It is to be noted that once the new race has developed on Essex, or any other hybrid of the same category in respect of blight resistance, it can perpetuate itself in any variety without losing its virulence. Such a situation is not considered a menace to the production of standard varieties since there is no indication whatsoever that they blight more readily with this race than with the common field race.

When leafroll scions are grafted on Essex a typical leafroll symptom is exhibited in the following clonal generation. In the field, however, the variety has not contracted leafroll when grown in test or seed plots where other test varieties did contract the disease. Tests are in progress to determine whether this is a natural field resistance or whether the plants usually are dead before insect vectors are prevalent. Donald Folsom has kindly reported the results of a first-year exposure in his leafroll test plot. Essex showed a pick-up of 62 per cent with clearly defined symptoms. Some other varieties in the same test picked up an even higher percentage of leafroll but it is obvious that Essex has acquired a reputation for leafroll resistance which it does not deserve.

In the same way, rugose mosaic has not been encountered in the field in Essex. Nevertheless, when virus-free plants are inoculated in the greenhouse with virus Y the plants react typically with veinstreak and leafdrop.

Graft inoculations with scions from plants carrying virus X give no reaction in the shoots which spring up from below the point of graft. Whether the variety is immune or is a symptomless carrier is not known.

Adaptation

Essex is very well adapted to areas where the seasons are cool and moist. By irrigation its range can be extended. It is not a variety for the general or dairy farmer.

Dissemination

Stock of Essex was released to seed growers in 1946 for increase. It has been widely distributed and is available in considerable quantity.

Glenmeer

Released for increase at the Rochester meeting of Empire State Potato Club, January, 1946.

Glenmeer is a sib of Essex and its pedigree is shown on a preceding page. Except for parentage the two varieties have little in common.

Glenmeer is a plant of determinate growth but the normal size of plants is about 4 feet tall with very thick, heavy stalks. The plants have a considerable resistance to drought and enough frost tolerance to escape the occasional light frosts of August or early September. The variety matures very late. Like Essex it sets a very heavy crop but with its tolerance for dry weather can produce a higher proportion of first class tubers providing freezing weather does not interrupt normal development. The tubers have a red skin and the cooked tuber is very palatable to those persons who like the variety Triumph.

Although it was evident relatively early that this hybrid had very restricted usefulness in New York there was a possibility that it might be of value in Florida. It was known that Florida growers of the Hastings area were switching reluctantly from the pink-skin Triumph to the white-skin Sebago. The latter variety is well known as a late-maturing sort in the north which yields very well when planted in January in Florida. Some preliminary tests of Glenmeer in north Florida indicate that it does not react like Sebago and that its growing season there is too long to make it of any value in the south.

The variety is subject to leafroll, rugose mosaic and scab with clearly defined symptoms when affected.

Madison

Released for increase at the Rochester meeting of Empire State Potato Club, January, 1947.

Madison is the result of straight backcrossing with *Solanum demissum* as the original source of resistance.

DUY-2 (Madison)
- Earlaine
- AMY-4
  - 860
  - A-2
    - 349
    - 450-1
      - 427
      - *demissum*

In this chart 427 is Erste von Frömsdorf from Cimbal; 349 is an unnamed seedling obtained from F. A. Krantz under the label 75. 25-5-27 (later designated 11-5-9); 860 is also a Krantz seedling numbered 41-2-10-1.

Madison is another variety with determinate growth. When the plants first emerge they form a wide spreading rosette. The leaves are exceptionally large and the leaflets exceptionally broad so that the ground is shaded very early in the season. The leaflets are strongly rugose. Plants are definitely tolerant of heat and drought. Growing season is about 105 days from planting to harvest. The tubers are as large and smooth as Katahdin. Oversize tubers develop rather readily and such tubers are likely to be hollowheart. The yield in test plots has equalled or exceeded that of Katahdin.

The cooking quality varies somewhat with location but is comparable with that of Katahdin grown under similar circumstances.

Madison is subject to leafroll, rugose mosaic and scab and shows well-defined symptoms of each when affected.

The variety is grown to a very limited extent at present. Its resistance to blight and its relatively early maturity make the use of a fungicide unnecessary. The early maturity makes it essentially a substitute for Cobbler a variety long in favor because it extends the harvesting period. The tendency to hollowheart, however, may prove to be serious enough to relegate the variety to oblivion.

The variety "emerged" in test plots on the farm of H. J. Evans in Madison County, New York.

Snowdrift

Released for increase at Rochester meeting of Empire State Potato Club, January, 1947.

Snowdrift has for its early ancestors the same parents as Chenango, a succession of unnamed seedlings until the third backcross stage was reached. At this point, one plant set seeds naturally. The progeny was grown but no immune plant was found which was as promising as the parent. However, one of these plants was crossed with Earlaine pollen. Snowdrift is a selection from the progeny of this cross.

Snowdrift appears to be a variety of restricted usefulness. It has been introduced largely because of the insistence of a collaborator, Professor A. J. Pratt, who singled it out early as a sort needed in the hill land of central New York. The character which appeals to him particularly is early maturity. The growing season from planting to harvest is about 105 days. Snowdrift is very much like Chenango and the statement of "characteristics" and "adaptation" made for Chenango in this Journal (24: 334) apply equally well to Snowdrift.

Commercial growers do not like the variety because of the weak

stems and because of poor yields of marketable tubers in dry years.

Market gardeners who have irrigation available might find this a highly desirable variety for extending their season. Under favorable conditions a very heavy crop of tubers of uniform size with unusually white skin and shallow eyes can be expected.

The name is derived from the fact that "mashed potatoes" of this variety are exceptionally white and suggest a snowdrift.

Fillmore

Released for increase at the Rochester meeting of the New York State Potato Club, January, 1947.

Fillmore is a sib of Empire. Its pedigree can be found in this Journal (22:358); Plants of this variety are invariably slow to emerge indicating the need for early warming of seed stock. The stalks are very sturdy from the beginning and the plants become very large and tall. The plants are essentially determinate and remain nearly erect until frost.

Fillmore resembles Glenmeer in many respects but is easily separated because of the strongly rugose leaflets. Terminal leaflets very commonly have a purplish tinge. The plants are decidedly tolerant of drought but have no tolerance for frost. Tubers are not as smooth as are those of the Rural parent and tubers lying near the surface of the ground usually show a distinct pinkish blush on the uppermost side. The color is accentuated in storage and after a few months the tubers are rather uniformly colored on all sides.

Fillmore is subject to leafroll, rugose mosaic and to scab. Rugose mosaic is difficult to detect in the variety. The natural rugosity of the leaflets is one factor which makes detection of mosaic difficult but in addition the symptoms of the disease are not sharply defined. The variety is, in fact, almost a symptomless carrier of virus Y.

The cooked tubers do not turn dark on standing as is the case with Rural New Yorker No. 2. It was thought at one time that Fillmore might prove a suitable substitute for Rural. There is no inclination at the present time to return to a very late-maturing variety so that it is highly improbable that Fillmore will be grown to any extent.

Harford

Released for increase at the Rochester meeting of the Empire State Potato Club, January, 1947.

Harford is a cross of Russet Rural by fertile inbred hybrid, AFY-5. The parentage of AFY-5 is shown in the diagram of Placid presented in this Journal (24:322). The variety is much like a "Rural" in most respects. The plants are indeterminate, the stalks grow fairly tall, then bend over and send up heavy growth from axillary buds so that the

row becomes densely covered. The plants have fully as much tolerance for adversity and in particular, for drought as the Rurals. Plants continue green until frost. The tubers approximate Green Mountain in size, shape, and in skin color. On a farm near Ithaca, Harford for two successive years outyielded significantly. Rural New York No. 2, Green Mountain, Katahdin and Chippewa. The variety might readily replace the Rurals if there were a desire to continue with any variety of such late maturity, and if Harford were immune from all races of the parasite. The variety is likely to disappear soon in New York but it has been distributed to various parts of the world and could persist somewhere for a good many years.

Cortland

Released for increase at Rochester meeting of Empire State Potato Club, January, 1947.

Cortland is the result of straight backcrossing three times. The only difference from the usual routine is that *S. demissum* was used as male parent in the first cross. Russet Rural was the female parent. Krantz' unnamed seedling 41-2-10-1 was used to secure the backcross, Katahdin for the second backcross and Menominee for the third backcross.

This variety is very much like Russet Rural in that it is of indeterminate growth, drought tolerant, goes down early and fills the row with a dense growth of axillary shoots. The tubers, however, are unusually "white" and smooth and are longer and a little more pointed than Russet Rural.

The variety is passive to virus X, susceptible to leafroll, rugose mosaic and common scab. In Florida, it is very susceptible to early blight and is thus precluded from use even though small tests indicate that it can produce a satisfactory crop there.

In Cortland County, New York, Cortland in replicated test plots was one of the three highest yielding varieties for three successive years. It was exceeded by Empire and Fillmore and equalled by Harford but the difference was not statistically significant.

With the thought that the variety might be useful in typical "Rural territory" in Western New York, it was included in a test plot of six replications in that area in 1946, although it had been dropped in some previous trials there. Of the nine main crop varieties it gave the lowest yield and it outyielded significantly by Katahdin (620 bus.) Rural New Yorker No. 2 (730 bus.) and Hartford (688 bus). It appears that Cortland does not have the inherent capacity to surge forward under highly favorable conditions and produce exceptionally heavy crops, a capacity well recognized in the Rurals.

The variety is not likely to persist long in New York because of virus

diseases. The variety is not widely adapted and it is unlikely that a seed producer will undertake to produce a variety of limited adaptation. Samples of the variety have been distributed to many parts of the world but there is no way to know at present whether Cortland will prove useful anywhere.

EFFECT OF IRRIGATION ON THE PRODUCTION OF WHITE POTATOES*

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(Accepted for publication June 30, 1949)

Potatoes, another shallow-rooted crop (15-18), give pronounced increased yields from irrigation in arid areas. This crop is of particular interest because it is grown widely and is an important food. In California, irrigation practices on potatoes range in extremes from non-irrigated fields along the coast to rather excessive use of water in the Kern County area. Previous workers have conducted irrigation studies with white potatoes in several western states. Publications on this research work, however, show that frequently neither the water applied nor the soil moisture was measured.

Review of Literature

Edmundson (10) gives a summary of potato irrigation practices in the West. The amount of water used varies with soil type and climate. In some areas, there is a need for preirrigation or "irrigating up" of the crop after planting. Some sections use 3 or 4 applications and others from 5 to 10, or even more. Since potatoes are a shallow-rooted crop, the application of 2 to 4 inches of water quite frequently is preferable to 4 to 5 inches at less frequent intervals. The soil should be kept continuously moist until the tubers are nearing full size. With inadequate water, the plant's growth is reduced and the leaves remain dark green; an excess of water produces foliage of light color. In most cases, the potatoes are irrigated with a surface application of water in ditches, but in San Luis Valley of Colorado and the Delta area of the Sacramento and San Joaquin rivers in California, the soil is wet by subirrigation.

Research in potato production has been rather prolific, and includes a considerable amount of work on irrigation. The methods of research for these projects were not identical, so the comparison of the results obtained is somewhat difficult. Measurement was usually made of yield but not always of the amount of water applied or the soil moisture con-

*Data on number of applications and inches of water applied in irrigation treatments have been supplied by L. D. Donnen of the Division of Irrigation.

tent of the plots. Growth measurements in many cases were limited to the gross appearance of the plants. The following papers contain good reviews of literature dealing with the various phases of irrigation: Edmundson (7, 9); Harris (13); and Harris and Pittman (14).

As might be expected most of the potato irrigation experiments have been conducted in the West. Harris and Widtsoe reported on some extensive tests on potatoes prior to 1920. There are many experiments in which the results show increased yields from irrigation. Important studies were made in the following regions: Alberta, Canada (19); Michigan (21); New Mexico (2, 3, 11); Oregon (20, 22); Utah (13, 14, 25, 28); and Washington (6). In some cases, unirrigated plots were compared with irrigated; in others, a small amount of water was compared with large amounts. The percentage increase of yield ranged from as low as 60 per cent up to a maximum of almost 300 per cent in different areas.

There was considerable range in the amount of water used and the frequency of irrigation. Frequently the maximum amount of water produced the greatest yield. There is no indication whether still more water would have increased the yield further. In Utah, Widtsoe and Merrill (25) obtained the greatest yield with 60 inches of water, but this heavy irrigation resulted in poor quality. A 20-inch application was next in yield and produced a larger amount of quality potatoes. An irrigation of approximately 2½ or 3 inches of water gave the best yield when an amount of water varying from 5 to 20 inches of total water was added. The rainfall was 15½ inches per year. Harris and Pittman (14) obtained best yields with 20 to 25 inches of water and with an application of about an inch per week. Excessive amounts of water were harmful to yield (rainfall 17 inches). Harris (13), in an earlier experiment, obtained the best yield with 1-inch weekly irrigations or a total of 13 inches of water. Ninety-six inches produced fewer potatoes than no irrigation treatment (rainfall 18 inches). Nevada workers (32) made a variety trial under irrigated conditions and used 53 inches of water. Powers (20), in the Williamette Valley, obtained maximum yields with 2 to 3 inches in a wet year and 5 to 6 inches in a dry year. Light irrigations of approximately 2 or 3 inches seemed best. Yield was increased about 150 per cent. Shattuck and Hutchison (22) ran tests in southeastern Oregon where 14 inches gave the best yield (rainfall 9 inches). Idaho workers (31) found that frequent and light irrigations gave much better quality potatoes. Larger irrigations sometimes gave greater yields but practically all the potatoes were No. 2's and culls. Palmer (19), in Alberta, Canada, did not get so great an increase from irrigation as did some other workers but obtained the largest yield when plants were irrigated every 10 days after starting to bloom (rainfall 18

inches). Claypool and Morris (6) did not measure the water, but estimated that 4 inches applied each week gave better yield than did lesser amounts. Edmundson (7) discovered that early and more frequent irrigations produced the greatest yield (rainfall, April to September, 8 inches). Edmundson also found in his comparison with light and heavy or excessive amounts of irrigation water that the yield was not greatly affected. Irrigation trials made in southwestern New Mexico, by Bloodgood (3), showed the greatest yield from 9 irrigations and an application of 25 inches of water (rainfall for year, 10 inches; March to June, 1½ inches). Garcia and Young (11) made irrigation tests in Valencia County in central New Mexico, and obtained the greatest yield from 3 irrigations. All treatments varied from 0 to 6 irrigations, where 3 irrigations were given, the interval was about 3 to 4 weeks between applications (rainfall, April to October, 10½ inches). Robey (21), working in Michigan, obtained the greatest yield from 7 applications of 1-inch each. Other fields receiving 4 or 6 similar applications produced lower yields. The rainfall during the growing period varied from 10 to 14 inches at the different locations.

Arkhangelskij (1) made a study of the amount of second growth occurring on approximately 25 varieties of potatoes. All varieties differed greatly from a few per cent to as high as 76 per cent of tubers with second growth. Potatoes with second growth also had a lower starch content.

Werner has reported on rotation potato experiments at the Box Butte Experimental Farm in western Nebraska in 1937 (29) and in 1944 (30). This is an area with an average rainfall, for 10 years, of 15.5 inches, with extremes of 9.0 to 21.9 inches in 1931-1940. Potatoes were produced primarily from rainfall stored in the soil. The best yields of potatoes were obtained on ground fallowed the previous year. Next in yield were crops after corn, and lowest were those that followed wheat. These results are related to the depth of rooting of the previous crop. After fallowing, there were 6.2 inches of stored water in the soil, and this produced 100 bushels of potatoes per acre. There were 3.4 inches after wheat, and the yield was 54 bushels. In addition, several inches of rain fell during the summer.

Widtsoe (26) found that there was a steady increase in total dry matter per acre as the amount of irrigation water was increased. Five inches of water produced 2,310 pounds of dry matter per acre; the yield increased up to 3,795 pounls for 45 inches of water. This increase in total dry matter is due to greater yield even though the percentage of dry matter is lowered by irrigation. Widtsoe and Stewart (27) report that the relative amount of irrigation water does not greatly affect the moisture content of potato tubers. However, nonirrigated potatoes are

usually somewhat higher in ash and protein content. Powers (20) found little difference in the palatability of irrigated and nonirrigated potatoes. The potatoes on the nonirrigated plots contained a greater percentage of dry matter, protein, ash, and starch. Smith and Nash (23) report that potatoes grown on irrigated plots exhibited lower specific gravities of the tubers.

Bushnell (5) was able to increase the depth of rooting of potato plants on a Wooster silt loam by adding nitrogen and phosphorus to subsoils. Werner (29, 30), found, in several of his experiments, that potato roots would obtain soil moisture from 5-foot depths.

Some growers have believed that the vigor, vitality, and yield of seed potatoes were lowered if they were produced on an irrigated soil. Edmundson (8) and Harrington (12) both worked on this problem and found little difference in yield when nonirrigated and irrigated seed sources were compared.

METHODS

Each year, there were four different treatments for the plots as follows: (1) A—dry, no irrigation water applied, the only soil moisture being that stored from winter rains or a preirrigation; (average rainfall 17 inches) (2) B—wet plot which received large applications of water varying from 18 to 50 inches in the different years; (3) C—medium plot where the water application varied from 7 to 29 inches; and (4) D—light irrigation which received 31/2 to 13 inches of water. In 1941 and 1942, the treatments received similar amouts of water and in 1943, considerably heavier amounts for all irrigation treatments. The water was applied in furrows between the rows.

These tests were conducted during the spring season of 1941, 1942, and 1943. Plots were replicated twice in 1941 and the crop was unfertilized. In succeeding years, the plots were replicated 4 times and fertilized with ammonium sulfate. In 1942, 700 pounds were applied broadcast and the next year, 500 pounds were drilled into the bed.

Certified White Rose potato seed was planted in rows 3 feet apart, with plants 1 foot apart in the rows. The seed was planted for the different years as follows: March 19, 1941; February 21, 1942; and February 13, 1943. Good cultural practices were used. In 1941, the potatoes were dug when the plants on all the plots were dead. Since the plants died first on the A-plot, and last on the B-plot, the digging was performed in the last 2 years as the plants died. After being dug, the potatoes were graded, and samples of No. 1's were stored to determine whether irrigation affected loss of weight in storage (50° F). A Yolo loam, used in these experiments, became very hard in the nonirrigated plots, so that the tubers were inclined to be rough. Specific gravity

TABLE 1.—*Effect of irrigation* on the growth of White Rose potatoes, 1941, at Davis, California.*

Treatment	Inches of Water Applied	Number of Irrigations	100 Lb. Sacks per Acre No. 1's	Pounds per Plant			Grade per Cent		Pounds per Tuber		Number of Knobby Potatoes per Plant
				1's	2's	Total	1's	2's	1's	2's	
A — dry	0.0	0	41	0.28	0.31	0.81	30.0	40.7	0.29	0.14	0.14
B — wet	18.0	10	102	0.70	0.48	1.40	48.9	34.2	0.34	0.19	0.38
C — medium	6.8	3	96	0.66	0.40	1.31	50.4	30.7	0.32	0.16	0.45
D — light	6.3	2	74	0.51	0.34	1.07	47.4	32.4	0.31	0.15	0.40
L.S.D. — odds: 19:1			13	0.09	N. S.	0.17	15.0	N. S.	N. S.	N. S.	0.11

*Planted: March 19, 1941. Spacing: 3 x 1 feet. Plot area 1/132 acres.
Replications: 2. Fertilizer: None. Harvested: All treatments July 9, 1941.

TABLE 2.—*Effect of irrigation* on the growth of White Rose potatoes, 1942, at Davis, California.*

Treatment	Inches of Water Applied	Number of Irrigations	100 Lb. Sacks per Acre No. 1's	Pounds per Plant			Grade per Cent		Pounds per Tuber		Specific† Gravity of Tubers	Storage No. 1's per cent Loss in Weight 3½ mos. 50° F	No. of Knobby Potatoes per Plant
				1's	2's	Total	1's	2's	1's	2's			
A — dry	0.0	0	166	1.14	0.45	1.62	71.0	27.6	0.42	0.20	1.0919	2.1	0.14
B — wet	19.4	7	370	2.55	0.60	3.27	78.0	18.4	0.61	0.24	1.0750	3.6	1.05
C — medium	7.7	3	277	1.91	0.50	2.41	79.3	20.7	0.51	0.25	1.0837	2.9	0.69
D — light	3.4	1	206	1.42	0.54	2.01	71.2	26.4	0.48	0.26	1.0835	3.8	0.34
L.S.D. — odds 19:1			86	0.59	N.S.	0.22	6.4	6.7	0.05	0.04	0.0029	0.60	0.33

*Planted: February 21, 1942. Spacing: 3 x 1 feet. Plot area: 1/104 acre.

†Percentage dry matter of tubers: A = 22.6 per cent; B = 19.8 per cent; C = 21.6 per cent; D = 21.1 per cent.

Replications: 4. Fertilizer: 700 lb. ammonium sulfate broadcast before planting.

Harvested: June 22 = A plots; June 29 = D plots; July 2 = C plots; and July 6 = B plots.

TABLE 3.—*Effect of irrigation* on the growth of White Rose potatoes, 1943, at Davis, California.*

Treatment	Inches Water Applied	Number of Irrigations	100 Lb. Sacks per Acre No. 1's	Pounds per Plant			Grade		Pounds per Tuber		Specific Gravity of Tubers	Loss of Weight in Storage 50° F per Cent	Number of Knobby Potatoes per Plant
				1's	2's	Total	1's	2's	1's	2's			
A—dry	0.0	0	90	0.62	0.49	1.18	52.5	41.5	0.41	0.27	1.084	5.6	1.72
B—wet	50.4	20	385	2.65	0.51	3.35	79.1	15.2	0.65	0.40	1.071	5.1	1.34
C—medium	29.1	10	331	2.28	0.41	2.89	78.9	14.2	0.65	0.40	1.073	3.1	1.19
D—light	13.2	5	260	1.79	0.48	2.38	75.2	20.2	0.58	0.37	1.077	3.3	0.48
L.S.D. — odds 19:1			57	0.39	N.S.	0.25	7.9	6.8	0.05	0.06	0.006	N.S.	0.35

*Planted: February 13, 1943. Spacing: 3 x 1 feet. Plot area: 1/104 acre.
Replications: 4. Fertilizer: 500 lbs. per acre of ammonium sulfate in bands.
Harvested: June 15 = A plots; June 30 = D plots; July 7 = C plots; July 13 = B plots.

determinations were made by weighing the individual potatoes in air and water. Standard methods were used for chemical analysis. If the tubers had knobs on them which were ½ inch in length, they were classified as knobby potatoes.

Results and Discussion

The data obtained in these experiments are reported in tables 1, 2, 3, and 4. Even though the soil was wet to a depth of 5 or 6 feet from winter rains, there was very small yield from the nonirrigated plots. Irrigation greatly affected yield of potatoes in each of the three years, and many of the differences were significant at the 5 per cent level. All

TABLE 4.—*Effect of irrigation treatment on composition of potatoes, 1942*

Treatment	Per cent Dry Matter	Per cent Nitrogen, Fresh Basis	Per cent Nitrogen, Dry Basis
A — nonirrigated	22.6	2.5	11.1
B — wet	19.8	2.1	10.4
C — medium	21.6	2.2	10.3
D — light	21.1	2.5	11.7

treatments were significant in 1941 except the B-C comparison. In 1942, there are fewer comparisons which are significant and the least significant difference is larger. The significant differences in 1943 are similar to those in 1941 and only the B to C comparison is nonsignificant. The application of nitrogen fertilizer gave a considerable increase in yield in 1942 and 1943 as compared with 1941.

At the end of the experiment, the amount of growth made was proportional to the irrigation water applied. There were considerable changes in the appearance of the plants in the different plots. The wet treatment (B) plants exhibited a light green color throughout the growing season, and this would indicate that they made continuous growth. When growth ceased or slowed down because of insufficient water, the plants became dark green in color. In the case of the dry (A) plots near maturity, the plants were a blackish green color. The appearance of this dark green color occurred first on the A plots, following in succession on D and C. The plants also exhibited some wilting, although this did not appear so quickly as the change in color. In all years, the A and D plots exhibited wilting, as did the C treatment at times.

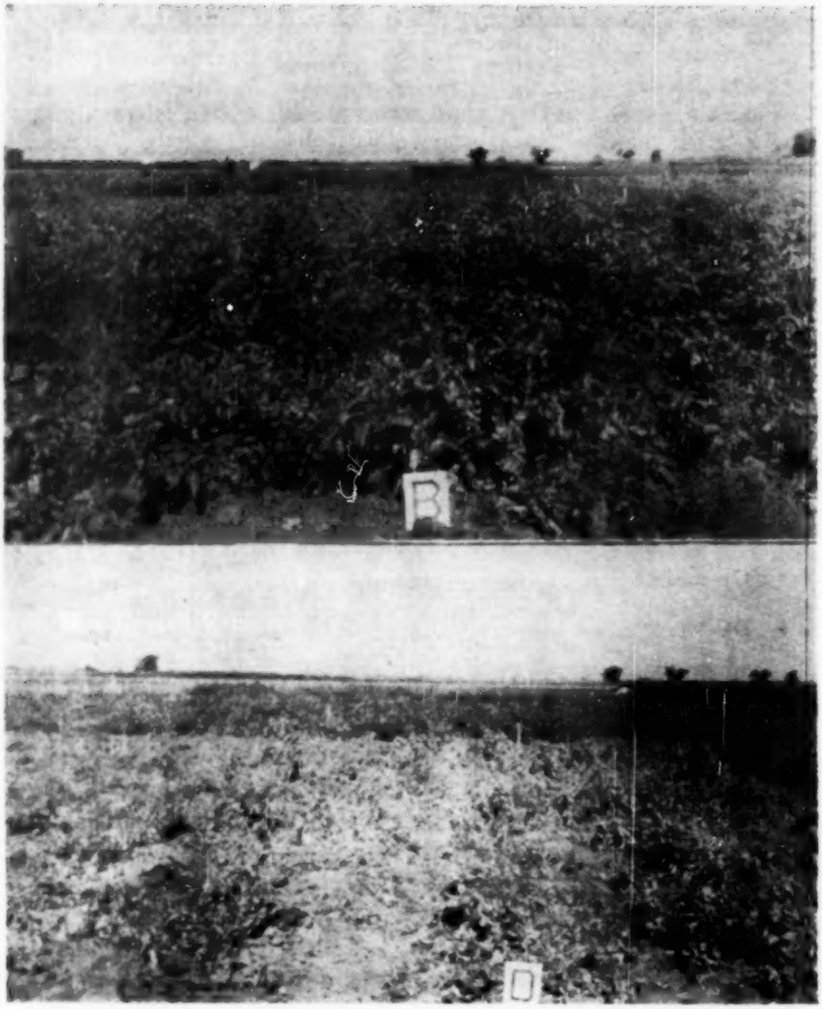

Fig. 1. Two irrigation plots for potatoes on July 8, 1942. Note that the plants on treatment D (3½ inches of water) have matured earlier than those on treatment B (19½ inches of water).

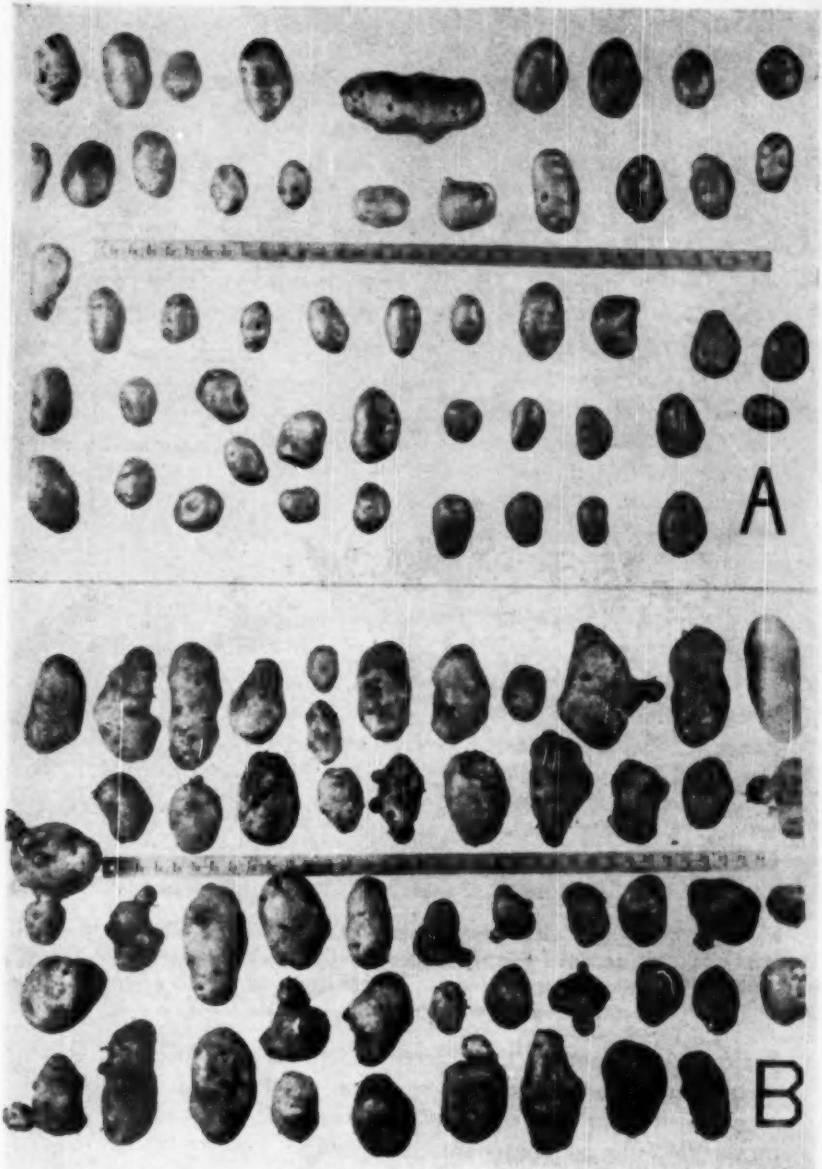

Fig. 2. Potato tubers from A treatment (no irrigation water) and B treatment (19½ inches of water). Note the relative amount of potatoes with "knobs or growth" (1942).

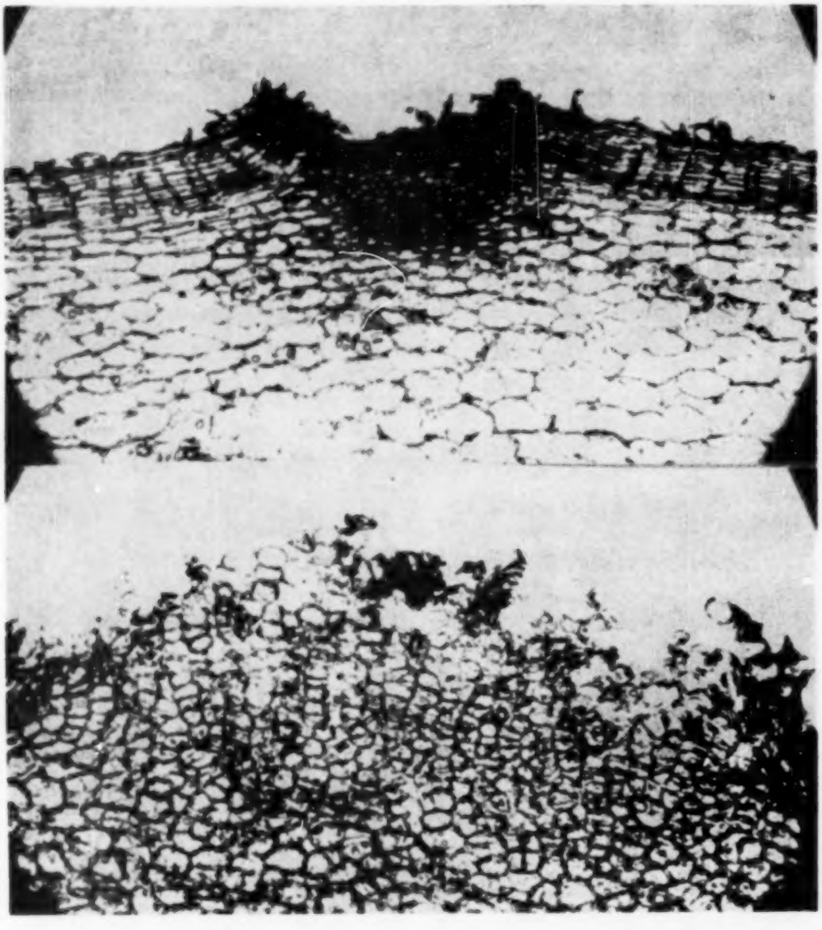

Fig. 3. When potatoes are heavily irrigated, they form large open lenticels. The above microphotograph shows a cross-section through a lenticel from the dry treatment (A) at the top and a similar lenticel from an irrigated potato at the bottom (B). (Prepared through the courtesy of Dr. L. K. Mann.)

Each year the plants on the different plots died in regular succession, in direct relation to the amount of irrigation water applied. A given plot was harvested when most of the plants were dead. In 1942 the harvest dates for the different plots were: A treatment, June 15; D treatment, June 30; C treatment, July 7; and B treatment, July 13 (Fig. 1). In 1943, there was severe wind damage the greatest being to the A and D plots.

The application of water was rather excessive in 1943 so there was

some standing water between the rows for a day or more. In 1941, there was a somewhat similar condition on one B plot due to a leaking standpipe. No harm was noticed, in these experiments ,from excessive irrigation, as has been true in some other Western experiments. This difference may have been caused by better soil drainage. In these experiments, it is believed that there was no building up of an underground water table.

Irrigation has produced several changes in the potato tubers. Each year, except 1941, showed some effect on size of both No. 1 and No. 2 potatoes produced by the different treatments. The material on knobby potatoes is of interest since it is generally believed that a cessation of tuber growth followed by good growing conditions will cause knobs. Each year, on the nonirrigated plot, there were some knobby or second-growth potatoes (Fig. 2). In 1943, this condition was more prevalent on the nonirrigated treatment. Irrigation treatments did not appreciably affect the loss of weight in storage. There were significant differences in 1942 but none in 1943. There was a considerable effect on the percentage of No. 1 potatoes. In all cases, the smallest percentage of No. 1 potatoes was found in the nonirrigated treatment. Size might have been a slight factor here, but a diameter of 1-7/8 inches usually is not too critical. Some irrigation experiments in other states have shown that excessive amounts of water may lower grade, but such was not true of these experiments.

Irrigation affects the composition of potatoes. An insufficient amount of soil moisture causes an increase in the percentage of dry matter and of nitrogen in the tubers. These results are found in table 4. Analyses of vegetables have shown that if growth is reduced because of a deficiency of some element, there is an increase in the other elements and usually in carbohydrates.

Irrigation treatment produced a noticeable effect on the appearance of the lenticels of the tubers. The nonirrigated potatoes have a normal, small appearing lenticel. The heavily irrigated potatoes exhibit a large, whitish tissue at the normal location for the lenticel. These differences in structure are illustrated in fiugre 3.

Summary

As the result of irrigation experiments conducted for three seasons, it was shown that the yield of potatoes was increased greatly by irrigation under the climatic conditions of Davis, in California. An application of 30 to 35 inches of water produced maximum yields. The nonirrigated potatoes produced a smaller percentage of No. 1s, were smaller in size, and usually had fewer knobs. The irrigated potatoes were usually of higher water content, had a smaller percentage of nitrogen, and exhibited large, whitish appearing lenticels.

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EFFECT OF GROWTH REGULATORS ON SPROUTING OF STORED TABLE STOCK POTATOES AND ON WASTE PILES FOR CONTROL OF DISEASES[1]

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The use of methyl ester of napthaleneacetic acid has proven generally satisfactory for suppressing sprout growth on stored Irish potatoes (2, 5). The development of a less expensive chemical sprout inhibiting treatment would be of particular interest to those who store large quantities for table stock or chip-making purposes.

Waste potatoes that are scattered or piled on the ground out-of doors also develop sprouts which harbor diseases and insects. Experience (1, 3) has shown that a primary source of infection for late blight, a very destructive disease of potato caused by *Phytophthora infestans* (Mont.) DeBy., is from sprouts developing on infected tubers. The cull piles often contain a considerable amount of late-blight-infected tubers. Young sprouts that develop on these tubers are infected and constitute a source of early seasonal infection for potato fields in the vicinity.

This report is concerned with experiments conducted during 1944-1948 to determine the relative merits of a number of growth regulators in inhibiting sprouting of potatoes for table stock or chipping purposes as well as cull potatoes that may influence the spread of diseases or insects.

Materials and Methods

In comparison with alpha-naphthylmethyl acetate the following esters were tested: methyl and ethyl esters of ortho- and of para-chlorophenoxyacetic acid; the methyl, ethyl, butyl, and amyl esters of 2,4-dichlorophenoxyacetic acid (2,4-D); the methyl, ethyl, butyl, and isopropyl esters of 2,4,5-trichlorophenoxyacetic acid; ethyl gamma-alpha-3-indolebutyrate, ethyl 2-iodo-3-nitrobenzoacetate and ethyl 2,3,5-triiodobenzoacetate. In addition 2,4-D was tested in combination with several less potent growth regulators, such as beta-indoleacetic acid, naphthaleneacetic acid, and phenylacetic acid.

In preparing aqueous suspensions or emulsions of the various compounds for dip treatment they were first dissolved in Carbowax 1500, Tween 20, or Emulphor AG (oil soluble). In some instances the acids were neutralized with triethanolamine and an aqueous solution of the amine salt was used for treating tubers. Shredded paper toweling was impregnated with the chemicals by first dissolving the compound in a measured amount of 95 per cent grain alcohol. This alcoholic solution was then absorbed by a weighed amount of paper, and the alcohol was dried off prior to treatment of the tubers.

Experimental lots of 6 to 36 pounds of tubers were used, depending on the type of information sought. Potatoes for table stock were stored either in common storage at fluctuating seasonal temperatures ranging from 35° to 55° F., or at room temperature of 65°-75° F., or at controlled storage temperature of either 40° F. or 60° F. Since volatile esters were used in many mixtures it was necessary to seal the experimental lots in cellophane or double-wall paper bags to avoid contamination of one treatment with another. Conditions designed to simulate cull piles were made by placing the treated tubers with moistened shredded sphagnum moss in 10-inch clay pans in a 65° to 75° F. greenhouse. The upper layers of tubers at the surface were barely covered with sphagnum, whereas the lower tubers were at a depth of 1 foot.

In field experiments, waste or cull potatoes were sprayed with growth regulators when the tubers were deposited on the waste piles.

Discussion of the Results

Treatment of Table Stock Potatoes.—Experiments, Season of 1943-1944.—Katahdin potatoes stored at 60° F. developed very few sprouts during 2 months' storage after dip treatment with alpha-naphthaleneacetic acid or the methyl ester of this acid, as shown in table 1.

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[1]Report of a study made under the Research and Marketing Act of 1946.
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TABLE 1.—*Effect of different growth regulators on sprouting of Katahdin potato tubers. Treatments applied on March 3, 1944, and results expressed as average percentage of tubers with sprouts on May 4, 1944. Twenty-five tubers for each treatment were sealed in double-wall paper bags and stored at 60°F.*

Growth Regulator	Sprouted			
	Conc. p.p.m.	Water Dip	*Wax Dip	Shredded Paper
		Per cent	Per cent	Per cent
Control (no treatment)	0	100	97	100
Alpha-naphthalene acetic acid	500	5.9	9.1	—
Methyl ester of acetic acid	500	2.3	7.4	**3.0
2, 4-Dichlorophenoxyacetic acid	500	100	100	—
Ethyl ester of Dichlorophenoxyacetic acid	500	—	—	**100
Ethyl ester of 2, 4, 5-trichlorophenoxyacetic acid	500	—	—	**9.7

*Food Machinery Corp. "Stafresh #810" diluted 1 to 4.
**Shredded paper was soaked with sufficient 500 p.p.m. solution of ester to give 1 gram of ester per 2 lbs. of potatoes.

The tubers used in this experiment were free from sprouts but the rest period had been broken by prolonged storage at 40°F. At the concentration used (500 p.p.m.) the aqueous dip was slightly more effective than that containing wax emulsion (Stafresh 810). The waxed tubers were brighter in appearance than the others. It is of interest that 2,4-D (acid) was ineffective in sprout retardation at 500 p.p.m. concentration; the tubers were not injured by dip treatment with this amount of chemical.

Shredded paper toweling impregnated with growth regulator esters and mixed with the tubers was very effective in preventing sprouting. Possibly the most significant effect of growth regulators noted in this experiment was the marked retardation in bud growth of tubers treated with the ethyl ester of 2,4,5-trichlorophenoxyacetic acid. The ethyl ester of 2,4-D on the other hand did not stop vegetative bud growth of the tubers.

In another experiment Katahdin potatoes that had been held in common storage were desprouted by hand on the 12th of April, 1944. Duplicate lots of 10 pounds each were then dip-treated with 0, 100, and 500 p.p.m. concentrations of the ethyl ester of 2,4,5-trichlorophenoxyacetic acid as well as of the ethyl ester of naphthaleneacetic acid. After surface drying the tubers were stored at 60° in sealed paper bags.

The tubers were examined after 23 days of storage, on the 4th of May. At this time the untreated tubers showed considerable resprouting. Lots treated with 100 p.p.m. concentrations of each compound were all

beginning to develop sprouts whereas those receiving 500 p.p.m. concentration were entirely free of new sprouts. In this test 2,4,5-T (ethyl ester) seemed to be about as potent as the ethyl ester of naphthaleneacetic acid.

Experiment, season of 1946-1947—Often closely related chemical growth regulators bring about quite different plant responses (4). An experiment was conducted, therefore, on Katahdin and Sebago potatoes with 10 esters of the phenoxy compounds, these chemicals being in general rather inexpensive. In addition, esters of benzoic and indole compounds were included; and the methyl ester of naphthaleneacetic acid was used to furnish a basis for evaluating bud inhibition.

As is shown in table 2, the methyl and ethyl esters of ortho-chlorophenoxyacetic acid and similar esters of para-chlorophenoxyacetic acid were ineffective in preventing sprouting; likewise, four esters of 2,4-D (methyl, ethyl, butyl, and amyl) also had little effect on sprout growth. The esters of 2,4,5-T (methyl and ethyl) that were tested caused very marked bud inhibition on potato. Another compound, ethyl gamma-alpha-3-indolebutyrate also reduced sprouting sufficiently to warrant further testing. The two benzoic acid derivatives failed to inhibit sprouting.

Experiment season of 1948-1949—Duplicate lots (6.5 lbs. each) of Katahdin and Irish Cobbler varieties of potatoes were included in a dusting experiment with the methyl ester of 2,4,5-T. In this experiment dusts containing 0, 0.1, 0.5, and 1.0 per cent concentration of the ester were prepared by dissolving weighed amounts of the chemical in 95 per cent alcohol and mixing the solution with weighed amounts of finely ground vermiculite. After the alcohol had evaporated the resulting ester-dust mixtures were applied to the tubers at the rate of 1 gram of dust per 6.5 lbs. of tubers. After treatment on December 9, 1947 the experimental lots were stored in sealed bags at room temperature and examined on the 14th of March, 1948 (95 days later).

Under the conditions of this experiment dust containing 0.1 per cent methyl 2,4,5-T did not prevent sprouting of either variety. The apical buds on all tubers in lots treated at this concentration had produced short stubby sprouts from ¼ to ½ inch in length, in comparison with the controls which had developed long slender sprouts on all tubers. Occasional knobby apical sprouts had developed on tubers treated with the 0.5 per cent dust whereas tubers dusted with the 1.0 per cent mixture were completely dormant at this time.

Individual five-pound lots of Cobbler and Katahdin tubers were also treated on the 12th of December, 1947, with shredded paper containing several esters of growth regulators. In this experiment the tubers and shredded paper were sealed in paper bags and held in common storage.

Sprout inhibiting effects were observed on the 4th of May, 1948.

The compounds used in this test were: the methyl, butyl, and amyl esters of 2,4-D; the methyl and butyl esters of a-naphthaleneacetic acid; the butyl and amyl esters of B-naphthoxyacetic acid; the ethyl ester of 2,4,5-trichlorophenoxyacetic acid, and the butyl ester of ortho-chlorophenoxyacetic acid. Each of these nine esters was used at the rate of 0.3 gram in 30 grams of shredded paper per 5-pound lot of tubers. Lots treated with shredded paper only and an untreated lot served as controls.

TABLE 2,—*Effect of various esters of growth regulating chemicals on sprouting of Katahdin and Sebago potato tubers. One gram of shredded paper impregnated with* 100 *milligrams of chemical was sealed in cellophane bags with* 6 *lbs.* (15 *tubers*) *each, on the* 6th *of December* 1946. *Record shows number of sprouts after* 112 *days at room temperature of* 68-75°*F.*

COMPOUND	Katahdin Fresh Wt. Sprouts	Sebago Fresh Wt. Sprouts
	Gm.	Gm.
Control, untreated	160	90
Methyl alpha-naphthylacetate	2	0
Methyl ortho-chlorophenoxyacetate	158	87
Ethyl ortho-chlorophenoxyacetate	162	85
Methyl para-chlorophenoxyacetate	121	60
Ethyl para-chlorophenoxyacetate	132	65
Methyl 2, 4-dichlorophenoxyacetate	129	62
Ethyl 2, 4-dichlorophenoxyacetate	131	64
Butyl 2, 4-dichlorophenoxyacetate	140	72
Amyl 2, 4-dichlorophenoxyacetate	136	63
Methyl 2, 4, 5-trichlorophenoxyacetate	6	2
Ethyl 2, 4, 5-trichlorophenoxyacetate	10	5
Ethyl gamma-alpha-3-indolebutyrate	15	7
Ethyl 2-iodo-3-nitrobenzoacetate	150	76
Ethyl 2, 3, 5-tri-iodobenzoacetate	148	72

During the storage period (144 days) the untreated control lots developed 93.3 and 177.0 grams of sprouts for Cobbler and Katahdin, respectively. The methyl and butyl esters of naphthaleneacetic acid and the ethyl ester of 2,4,5-trichlorophenoxyacetic acid almost completely prevented sprouting. Several sprouts developed in each of these lots but all were short and knobby and the total weight per lot was less than 5.0 grams. In contrast the esters of 2,4-D, of ortho-chlorophenoxyacetic acid, and of B-naphthoxyacetic acid had but slight or no effect on sprout development.

TREATMENT OF CULL POTATOES

Experiment 1, *season of* 1946-1947. Preliminary studies conducted in the greenhouse on late-blight-infected Katahdin tubers during the winter of 1946-1947 indicated that water dips or sprays of naphthal-

eneacetic acid at 1000 p.p.m. concentration did not prevent sprouting. At 2000 p.p.m. concentration, however, the chemical prevented sprouting under warm, moist conditions favorable for plant growth. Late-blight-infected tubers rotted rather quickly, often before the bud-inhibiting effects of the various growth regulators could be evaluated. In further experiments, therefore, tubers free from late-blight were used and relatively higher concentrations of the various growth regulators were employed. In improving the methods used, untreated tubers placed in 10-inch pans and packed with moist sphagnum moss developed numerous sprouts which often grew to a height of 2 feet in the greenhouse. This method of simulating cull pile conditions was therefore used in comparing sprout inhibiting effects of various growth regulators.

Experiment 2.—Further evidence that 2,4,5-T has powerful growth-inhibiting effects on Katahdin potatoes was obtained in an experiment started on the 18th of March, 1947. Sprouted and dormant tubers dip treated with .25 per cent concentration of 2,4,5-T on this date and placed in pans packed with sphagnum in the greenhouse, were entirely free of sprouts on the 3rd of June (67 days later). Sprouts present on some of the lots at time of treatment were killed back to the tubers and did not develop further. Untreated potatoes during the course of the experiment developed some sprouts that were 2 feet or more in length, the average being 18.7 and 22.6 inches, respectively, for those active and those dormant at time of treatment. (Table 3.) Naphthaleneacetic acid and 2,4-D at dip concentration of 0.25 per cent reduced sprouting but failed to give complete control.

Dip treatments containing .125 per cent of either naphthaleneacetic acid or phenylacetic acid in addition to .125 per cent concentration 2,4-D did not increase the effectiveness of 2,4-D in sufficient amount in table 3, to give 100 per cent control of sprouting as you will not. Likewise the addition of indoleacetic acid, naphthaleneaceic acid, or phenylacetic acid, respectively, to 2,4-D so as to give .125 per cent dip concentration of each chemical did not increase the effectiveness of 2,4-D to a point where it was equal to .25 per cent dip concentration of 2,4-D alone.

Experiment 1, season of 1947-1948.—Newly harvested Katahdin tubers, the rest period of which was not broken by natural means, were used in a greenhouse experiment to determine if treatment with 2,4,5-T would prevent sprouting of tubers that had been treated with sodium thiocyanate to break the rest period. Cut tubers (approximately 2 to 4 oz. size) were soaked in 1.5 per cent concentration of sodium thiocyanate for 1.5 hours on the 28th of October, 1947. Individual lots of 20 pieces each of cyanate-treated and untreated seed pieces were dipped and packed in pans with moist sphagnum. Other cyanate-treated and untreated lots were removed from the sphagnum and 2,4,5-T applied

TABLE 3.—*Effect of various growth regulators on sprout development of Katahdin potato tubers held under moist conditions in a warm greenhouse (65° to 75° F.). All growth regulators were applied as dip treatment in water mixture together with 1.0 per cent Emulphor (AG), on the 16th of March, 1947. Record obtained on the 3rd of June, 1947. Some lots had sprouted, others were dormant at time of treatment.*

Growth Regulator Treatment	Number of Sprouts Dormant*: growing**		Total Length of Sprouts Dormant: growing		Average Length of Sprouts Dormant: growing	
	A	B	A	B	A	B
			Inch	Inch	Inch	Inch
Control	16	19	363	354	22.6	18.7
NAC 0.25 per cent	3	5	20	28	6.6	5.6
2, 4-D 0.25 per cent	4	0	38	0	9.5	0.0
2, 4, 5-T 0.25 per cent	0	0	0	0	0.0	0.0
NAC .125% plus 2, 4-D .125 per cent	20	16	236	355	11.8	19.7
PHEN. " " " "	14	4	259	31	18.5	7.8
IAC " " " "	19	12	292	100	15.4	8.3
NAC " " " "	11	12	238	222	21.6	18.5
PHEN. " " " "	12	2	56	11	4.6	5.5

*Tubers dormant at time of treatment. (A)
**All tubers having sprouts ½ to 2 inches long at time of treatment. (B)
SYMBOLS: NAC = alpha-naphtaleneacetic acid
2, 4-D = 2, 4-dichlorophenoxyacetic acid
2, 4, 5-T = 2, 4, 5-trichlorophenoxyacetic acid
PHEN. = phenylacetic acid
IAC = beta-indoleacetic acid

immediately into 2,4,5-T (acid) solution at .25 per cent concentration on the 20th of November, 1947, at the time sprouting had started.

All lots of freshly cut tubers that were treated with 0.25 per cent concentration 2, 4, 5-T in this experiment has rotted down 100 per cent by the 25th of November. Pieces that had developed suberized cut surfaces before receiving the growth regulator treatment on the 20th of November were all in sound condition when examined 115 days after the start of the experiment (February 20, 1948). Untreated controls started sprouting at this time, whereas the cyanate-treated controls had developed sprouts 1 to 2 feet in length. Cyanate-treated lots that received the delayed application of 2,4,5-T were sound but not sprouting at this time.

Experiment 2, season of 1947-1948. On the 12th of December, 1947, Katahdin and Cobbler tubers were dipped in aqueous solutions containing 0.20 per cent concentration of the triethanolamine salt of the following phenoxy acids: ortho-chlorophenoxyacetic, para-chlorophenoxyacetic, 2,4-dichlorophenoxyacetic, 2,5-dichlorophenoxyacetic, 2,6-dichlorophenoxyacetic, 2,4,5-trichlorophenoxyacetic, and 2,4,6-trichlor-

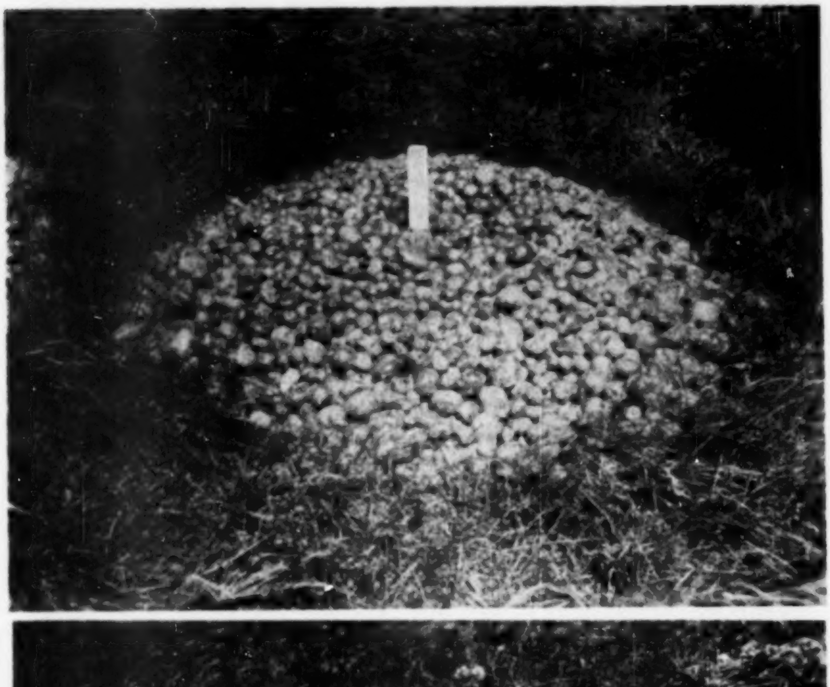

Figure 2. Top, potato culls treated on the 4th of June 1948, by spraying every layer with 2,500 pp.m. isopropyl ester of trichlorophenoxyacetic acid. (Photographed August 5, 1948.) Bottom, control, not treated.

ophenoxyacetic acids. Four lots of 15 tubers each (6.5 lb.) of the two varieties were used for each compound tested. Each lot was placed in sphagnum in the greenhouse as previously described.

On the 7th of April, 1948, after 117 days, tubers in all treatments excepting those treated with 2,4,5-T had sprouted profusely. Pans of tubers treated with 2,4,6-T consistently produced greater number and length of sprouts than the untreated lots which suggests that this compound may have stimulated rather than retarded the growth of sprouts.

Preliminary field experiments were also conducted in 1947 on cull piles of 1-barrel to 2-barrel size in Maine In this work 2,4-D (acid) and 2,4,5-T (acid) were tested at 2500 p.p.m. spray concentration with 1.0 per cent Emulphor AG as a solubilizing agent in the spray. Each layer of tubers was sprayed on the 21st of June when the tubers were deposited on the cull piles. Under field conditions 2,4-D did not greatly inhibit sprouting in comparison with the untreated controls. 2,4,5-T prevented sprouting on 1-to 1-½-barrel lots of tubers throughout the period of the 21st of June to the 1st of October. Treatment was best when applied to tubers that were spread out in a thin layer of 1- to 3-tuber depth so that all the tubers were wetted by the spray. Spraying of 2,4,5-T applied at the rate of ½ gallon per barrel of tubers to the outer surface of coneshaped piles did not prevent sprouting of tubers well within the pile.

These results indicate that a greater volume of spray than that used is necessary to penetrate into cull piles, and suggest that applications of the volatile ester forms of 2,4,5,-T may be more effective in preventing sprouting since the ester fumes would continuously treat over a long period the sprouts that may tend to grow from within the piles.

Further trials under field conditions in Maine were made during the summer of 1948. In this work potatoes having sprouts 1 to 3 inches long that had developed in storage were piled to depths varying from 8 to 14 inches. Some of the piles were composed of whole potatoes of mixed seedling stock, others were composed of leaf-roll-infected tubers of Katahdin, Chippewa, and Green Mountain varieties, whereas some consisted of cut seed-potatoes of mixed varieties. Every layer of 1-tuber depth was sprayed while the tubers were being deposited on the waste piles, to insure complete coverage of the tubers with the dormancy treatments. Four piles of each type of tuber were made up on the 6th of June, 1948, and three of each were sprayed with the isopropyl ester of 2,4,5-T, the butyl ester of 2,4,5-T, and the methyl ester of naphthaleneacetic acid, respectively. Each ester was applied as an aqueous suspension at 0.25 per cent concentration together with 0.25 per cent machine oil (SAE 20) emulsified with the aid of 1.0 per cent Emulphor AG

(oil soluble). Four comparable piles were left untreated for comparison.

Under the conditions of this experiment each of the esters tested prevented sprouting. Sprouts present at the time of treatment were completely checked. By the 5th of August, 1948, the untreated piles had developed tops from 12 to 16 inches tall while the spray-treated piles were free of plants (Fig. 1). At the concentration of esters used the tubers were not injured sufficiently to induce rotting.

SUMMARY

Results with certain growth regulators or dormancy treatments indicate that sprouting and subsequent development of late blight on potato waste piles can be prevented if the cull potatoes are treated with dormancy treatments before or when the tubers are deposited on the cull piles.

Literature Cited

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STUDIES ON BLACKENING OF POTATOES AFTER COOKING

In this book are given the general characteristics of stem-end-blackening of potatoes, and its effect on the cultivation and sale of potatoes. Literature containing a direct treatment of the subject is quite scarce, and only during the most recent years has an increasing interest in this problem evinced itself. However, considerable disagreement exists as to chief factors affecting discoloration.

In the first chapter various systems of rating the discoloration are mentioned. A summary is also given of the methods described in the literature, but none of these can be considered satisfactory. Following this summary is given a description of the color scale which the author has developed by photographical means. This scale has 10 steps, the reference color being rated as 1, and the darkest color as 10. The reference color is found in three shades of yellow. The scale is further characterized by the fact that the density within the measuring range employed increases linearly with the color rating.

The tyrosine-tyrosinase reaction and data are given on the

enzyme; mention is also made of the effect of the o-diphenols on the enzymatic process. In the same connection is given a summary of the existing literature on the importance of phenolase to the respiration of the potato.

The discoloration theories that have been advanced to date are also mentioned briefly. It has been brought out that discoloration has, for the most part, been attributed to the enzymatic oxidation of tyrosin involving the formation of the pigment melanin. However, recent researches show that this view cannot be correct inasmuch as the pigment formed is easily soluble in weak acids. Discoloration was then attributed to oxidized o-diphenols or, possibly ferric oxide, but in no case is a satisfactory explanation given. As to the influence of the hydrogen ion concentration on blackening, opinion is divided.

A summary of the cultivation experiments mentioned in literature, and an account is given of the experiments which have been carried out on the experimental farms of *De Danske Spritfabrikker*, and at the initiative of *Kartoffelkvalitetsudvalget*.

Two results deserve particular mention: first, that the discoloration increases with the N/K ratio of the fertilizer and that discoloration is inhibited by early destruction of the potato top or by early harvesting.

Chapter six contains the conclusion formed from all facts put forward in the preceding chapters and the working hypothesis for which they have served as basis. First, by calculating the amount of available intercellular oxygen it is demonstrated that enzymatic formation of colored quinones is not possible if the ascorbic acid content is taken into account. This calls for a different interpretation of the arguments offered in defense of the tyrosinase theory, such as the presence of higher tyrosinase activity in the tubers which blacken after cooking, whether this is due to the higher pH or the higher o-diphenol content in such tubers. With these facts in mind, and with existing literature on iron cathechol compounds as basis, the author advances the theory that potato discoloration after cooking is due to the fact that the ferro ions of the tuber combine with an o-diphenol to give a colorless or at any rate weakly colored compound, which oxidizes instantaneously when exposed to air, forming the corresponding strongly colored ferri compound. During cooking, the ferri ions of the potato are precipitated with the proteins and are thus excluded from the process.

Emphasis is also placed upon the fact that the discoloring compound contains iron and o-diphenol. The coaction of the iron is demonstrated by cooking potatoes in a pyrophosphate solution, which results in the formation of colorless iron-pyrophosphate complexes and a consequent decoloration. The coaction of the o-diphenol is demonstrated in like manner by treating potatoes with a boric acid solution. In this case and

at any rate partial discoloration takes place, the boric acid forming specific colorless complexes with o-diphenols.

The influence of the hydrogen ion discoloration is also well treated in this book review. In these studies determinations are made of corresponding values of discoloration and pH in 5 samples of potatoes from different localities. The results found are statistically treated, and in all samples the same linear correlation of the color rate with pH is demonstrated. It is also demonstrated that other factors besides pH affect the intensity of the discoloration, and that pH is highest in the stem end of the tuber, which explains the stronger discoloration there; likewise, it is demonstrated that a relaxation exists between pH and the increased discoloration due to high N/K ratio in the fertilizer, as well as between pH and the slighter discoloration caused by early harvesting.

A summary of the literature on the o-diphenol content of potatoes and the attempts made at isolating that substance are also given. Next a description is given of the method of analysis used for o-diphenol determination in potatoes. This method makes use of the fact that an o-diphenol solution to which nitrite has been added, and which has subsequently been made alkaline, assumes a red color. The calibration curves for catechol caffeic acid and potato juice, as well as the absorption curves for the red reaction products, show the o-diphenol of the potato to be closely related to caffeic-acid. Both ultraviolet spectrography and titration of potato extracts with iodine and iron corroborate this assumption. Subsequently, the o-diphenol was isolated, and this substance was identified by various means (such as elementary analysis) as caffeic acid. Closer investigation seems to indicate that potatoes contain a mixture of caffeic acid and chlorogenic acid.

Further investigation in this field show that the o-diphenol content is often highest in the stem end, and that a high N/K ratio in the fertilizer promotes the formation of o-diphenol. It was also found that unripe tubers contain this substance in the greatest quantity.

The author then gives a summary of the literature which is available on the iron content of potatoes. He then gives an account of the method of analysis developed by the author for the determination of ferro ions in potatoes. The method is colorimetric, and o-phenantroline is used as a reagent. It is demonstrated that the ferro ion content in potatoes is unaffected by the N/K ratio of the fertilizer, and determination of corresponding values of pH, discoloration, and ferro ion concentration, proved that no relation exists between the two latter factors in the material under examination. However, a comparison between the ferro ion content in samples from different localities did provide an indication that blackening, as might be expected, increases in intensity with the ferro ion content.

The author's summary also contains a detailed treatment of the reaction between iron and o-diphenol. Thus, absorption curves for potato juice to which ferrosulphate has been added have been plotted at different values of pH. The curves show the color changes which are so characteristic of iron-o-diphenol compounds and which occur with changes in pH. Furthermore, it is seen that between pH 5.1 and pH 6.3 the logarithm of the color intensity increases linearly with pH, which conforms to the results found in practice by using the color scale. It is proved that the rise in color intensity with increasing pH is due to the fact that the complexity of the iron caffeic acid complex increases considerably more at rising values of pH that in the case of other iron complexes. Lastly, it is proved that ascorbic acid is without influence on the formation of iron o-diphenol compounds in potato juice.

The results achieved may be summarized as follows:

Stem-end blackening increases at rising values of pH, because any increase in pH increases the complexity of the iron caffeic acid compound more than in the case of other iron complexes. Discoloration increases with the ferro ion concentration since this increases the amount of iron caffeic acid complex. Discoloration is dependent on the concentration of caffeic acid and on other ions and molecules forming iron complexes since the ratio of these concentrations determines the amount of caffeic-acid complex formed.

The author briefly mentions the factors which are of importance to the hydrogen ion concentration of the potato. By electrometric titration of boiled potato juice it is demonstrated that a high N/K ratio in the fertilizer is attended by a decrease in buffer capacity in the range pH 5.0 to pH 6.5. Since this must be presumed to be connected with a decrease in organic acid content, determinations were made of corresponding values of pH and citric acid. A well defined connection was found to exist between pH and citric acid content, a rise in citric acid concentration being attended by a decrease in pH. A summary is given of such examples of acid production in plants as are known from the literature, and the theory is advanced that it is by producing citric acid that the potato plant provides the hydrogen ions required for the exchange of cations.

Finally, the author mentions and discusses the commonly known household of preventing blackening after cooking, and the use of pyrophosphate is suggested.

It might be well to mention that the appendix contains descriptions of two pieces of apparatus designed by the author: A photoelectric colorimeter and a device for the securing of small samples of potato juice.

(*Translated by Mogens Kunst*)

"Studier over kartoflens morkfarvning efter kogning"
by Flemming Juul
Published by Julius Gjellerups Forlag
Kobenhavn 1949

MINUTES OF THE ANNUAL MEETING

Kansas City, Missouri December 8, 1949

The meeting was called to order by O. D. Burke with O. L. Wyman acting as secretary.

J. C. Campbell presented the Treasurer's report, which is printed below.

Statement for the Year Ending November 30, 1949
Treasurer's Report

Receipts		
Balance on hand November 30, 1949	$2,830.98	
Annual Dues	2,582.79	
Sale of Advertising	3,324.63	
Sale of Reprints	547.90	
Miscellaneous	106.75	
Total Receipts		$9,393.05
Disbursements		
Printing and mailing of Journal (12 issues)	$4,635.69	
Printing of Reprints	514.40	
Mailing and Supplies	631.10	
Editorial Work	400.00	
Secretarial Work	655.00	
Miscellaneous	312.09	
Total Disbursements		$7,148.28
Balance on hand November 30, 1949		$2,244.77
Accounts Receivable		
Advertising—Sept. and Oct. Approx.	$ 420	
Reprints—Billed and not paid	165	
N. J. group membership Approx.	555	$1,140.00
Accounts Payable		
Reprints (Printing)	$ 33.30	
Printing of October issue	$365.95	
Total		$ 409.25

JOHN C. CAMPBELL, *Treasurer*

The Editor's report was presented by J. C. Campbell and was accepted.

Report of the Auditing Committee

Frank Garrett reported that the auditing committee had examined the records and found them correct.

The following officers were elected for 1950:

President—H. A. Reiley, Michigan

Vice-President—Reiner Bonde, Maine

Director (for three years)—Robert D. Pelkey, Idaho

The following resolutions, presented by R. H. Larson, were adopted:

That the Secretary be instructed to thank the Kansas City Convention and Visitors Bureau for its help during registration of members.

That this Association express its appreciation for the excellent services rendered during the past year by O. D. Burke, *President;* Wm. H. Martin, *Editor* of the Journal; J. C. Campbell, *Treasurer;* and Ora Smith, *Secretary.*

That we express our appreciation to the Hotel Phillips for their cooperation in furnishing meeting rooms and other accommodations and to E. M. Swisher, Rohm & Haas Company, for assisting in making local arrangements for the meetings.

O. L. Wyman
Secretary, *Pro tem*

Minutes of Meeting of Executive Committee, December 8, 1949

An invitation was extended to the Association to meet in Toronto, Canada. After some discussion, it was voted that first choice is to meet with the American Society of Phytopathology, assuming that this would be in December. Final choice is to be made by the Executive Committee after conferring with officials of the Phytopathological Society.

J. C. Campbell was re-elected Treasurer of the Association for a two-year period.

The following committees were appointed:

Potato Introduction Committee

Donald Reddick, F. J. Stevenson, C. O. Erlanson, W. A. Riedl, J. C. Miller and G. H. Rieman, *Chairman.*

Certification Committee

E. L. Newdick, J. W. Scannell, W. H. Dunlap, Marx Koehnke, B. F. Branstetter and H. M. Darling, *Chairman.*

Membership Committee

W. L. S. Kemp, Frank Garrett, John Bushnell, H. J. Evans, Don Umphrey, R. D. Pelkey, J. C. Campbell, Ora Smith and Marx Koehnke, *Chairman.*

Visual Education Committee

R. J. Haskell, Wm. Keenan and Gordon Brandeis, *Chairman.*

It was decided to print the 25 year-index of the American Potato Journal, to be sold at 3 dollars a copy.

It was voted that the Editor place an off-color sheet notice of the annual meeting in the Journal in the two issues immediately preceding the Annual Meeting.

It was voted that the annual dues for Canadian members be $2.00 U. S. currency plus any bank exchange.

Honorary Life Membership Committee

Marx Koehnke, chairman of the Committee on Honorary Life Memberships, recommended that life memberships be presented to Dr. Donald Reddick of Cornell University and Dr. E. S. Schultz of the United States Department of Agriculture. This recommendation was unanimously approved and appropriate citations are to be printed in an early issue of the Journal.

Ora Smith, *Secretary,*